LEND PDS Data
LPSC 2015

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PDS Products

- PDS Geosciences node
  - http://pds-geosciences.wustl.edu/missions/lro/lend.htm
- EDR
  - Science – EDR_SCI
  - Housekeeping – EDR_HK
- PDR
  - Science with Spatial – RDR_RSCI
  - Reduced Science – RDR_DLD
  - Averaged Science – RDR_ALD

DLD and ALD data sets

LEND_RDR_ALD.FMT

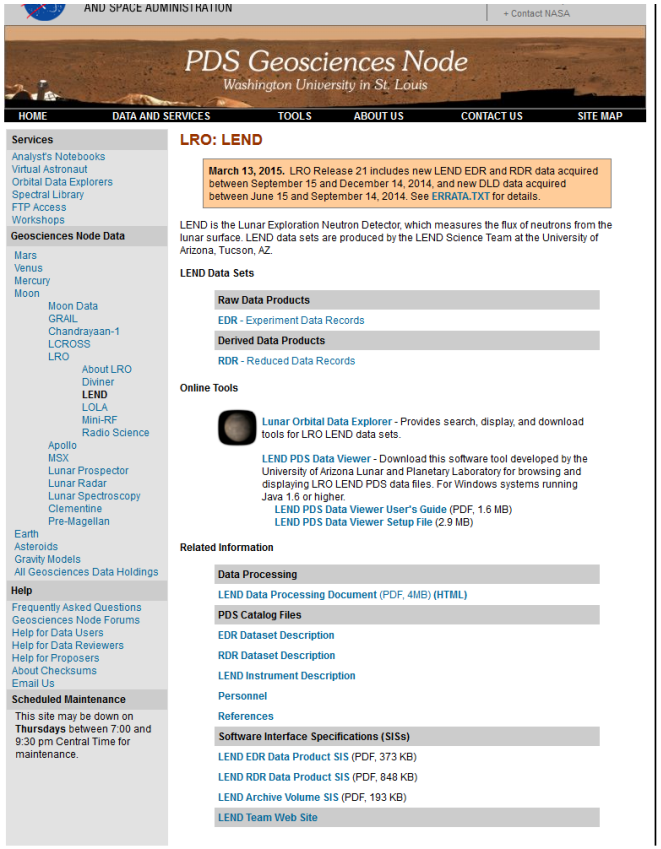
```
OBJECT = COLUMN
   COLUMN_NUMBER = 1
   NAME = START_UTC_TIME
   DATA_TYPE = CHARACTER
   BYTES = 23
   START_BYTE = 1
   DESCRIPTION = "UTC time at the start of the averaged frames,
   stored as yyyy-mm-ddThh:mm:ss.sss."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 2
   NAME = STOP_UTC_TIME
   DATA_TYPE = CHARACTER
   BYTES = 23
   START_BYTE = 24
   DESCRIPTION = "UTC time at the end of the averaged frames,
   stored as yyyy-mm-ddThh:mm:ss.sss."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 3
   NAME = LUNARCENTRIC_LATITUDE
   DATA_TYPE = IEEE_REAL
   BYTES = 4
   START_BYTE = 47
   UNIT = DEGREE
   DESCRIPTION = "Latitude in LUNAR fixed coordinates at the
   center of the given map element."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 4
   NAME = LUNARCENTIC_EAST_LONGITUDE
   DATA_TYPE = IEEE_REAL
   BYTES = 4
   START_BYTE = 51
   UNIT = DEGREE
   DESCRIPTION = "Longitude in Lunar fixed coordinates at the
   center of the given map element."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 5
   NAME = EXPOSURE
   DATA_TYPE = IEEE_REAL
   BYTES = 4
   START_BYTE = 55
   UNIT = SECOND
   DESCRIPTION = "Exposure time of given map element, sec."
```

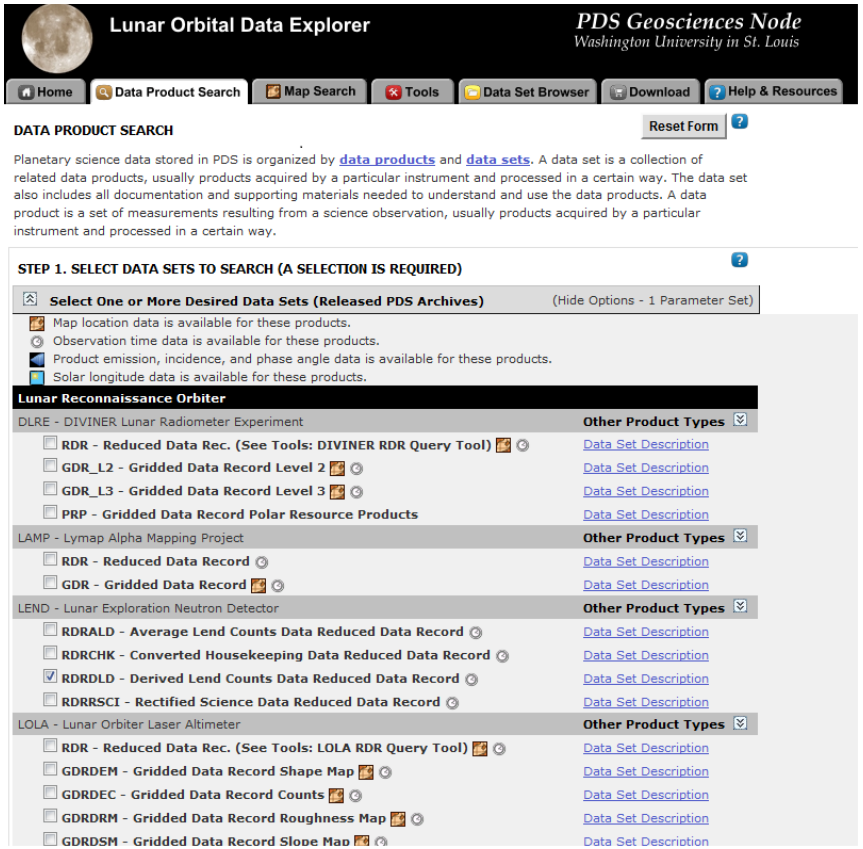
LEND_RDR_DLD.FMT

```
OBJECT = COLUMN
   COLUMN_NUMBER = 1
   NAME = LRO_TIME
   DATA_TYPE = MSB_UNSIGNED_INTEGER
   BYTES = 8
   START_BYTE = 1
   DESCRIPTION = "5 upper bytes of LRO time."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 2
   NAME = UTC
   DATA_TYPE = CHARACTER
   BYTES = 23
   START_BYTE = 9
   DESCRIPTION = "UTC time at the middle of the collection interval,
   stored as yyyy-mm-ddThh:mm:ss.sss."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 3
   NAME = LOCAL_HOUR
   DATA_TYPE = MSB_UNSIGNED_INTEGER
   BYTES = 1
   START_BYTE = 32
   UNIT = MINUTE
   DESCRIPTION = "Local Sun hour at the sub-spacecraft point."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 4
   NAME = LOCAL_MINUTE
   DATA_TYPE = MSB_UNSIGNED_INTEGER
   BYTES = 1
   START_BYTE = 33
   UNIT = MINUTE
   DESCRIPTION = "Local Sun minute at the sub-spacecraft point."
END_OBJECT = COLUMN

OBJECT = COLUMN
   COLUMN_NUMBER = 5
   NAME = LUNARCENTRIC_LATITUDE
   DATA_TYPE = IEEE_REAL
   BYTES = 4
   START_BYTE = 34
   UNIT = DEGREE
   DESCRIPTION = "Latitude in LUNAR fixed coordinates at the middle
   of the frame."
END_OBJECT = COLUMN
```

Geosciences Web Site

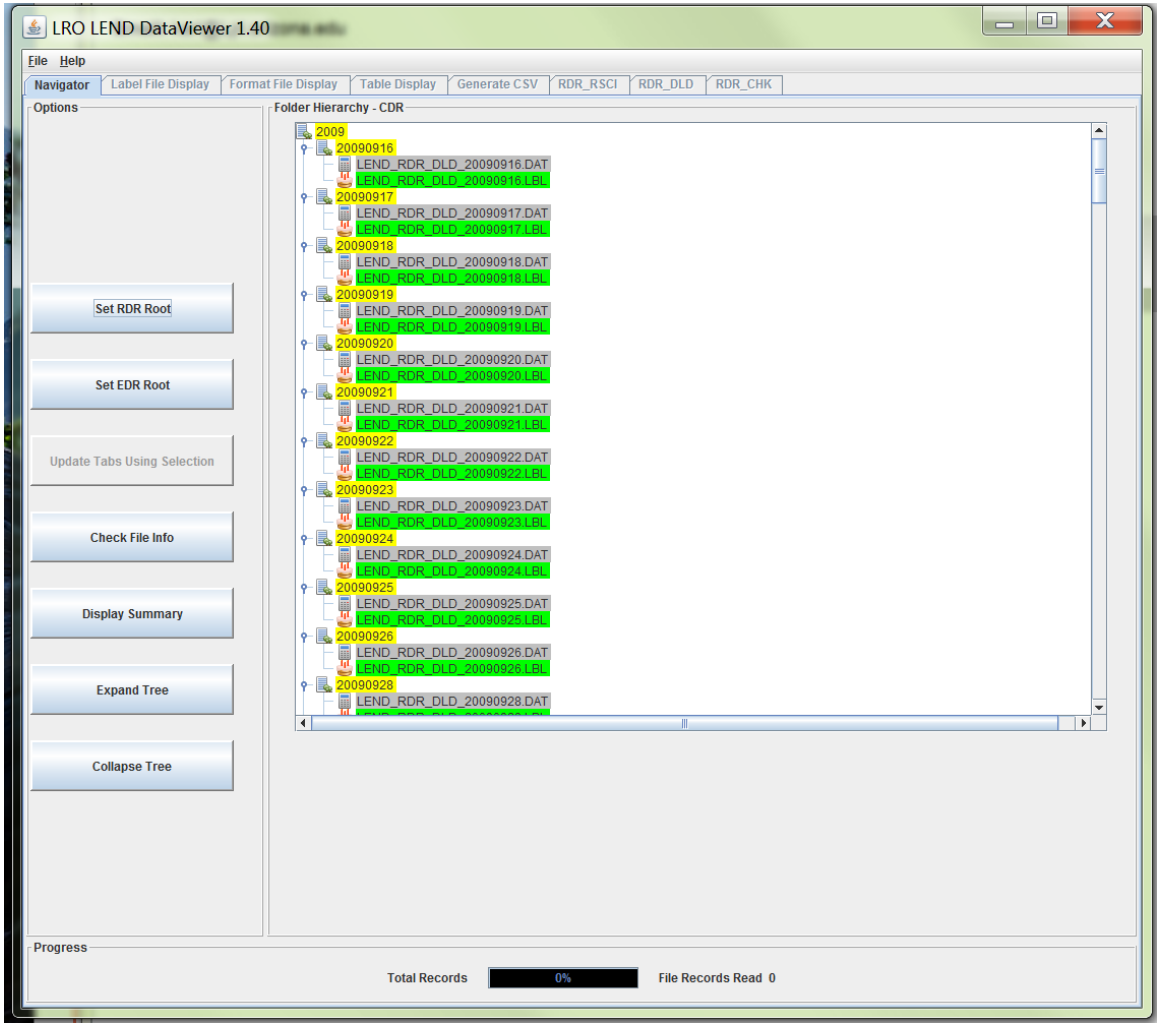
- http://pds-geosciences.wustl.edu





Available Tools

- NASA View
  - PDS provided
- LEND PDS Viewer
  - University of Arizona provided



How data can be used

- DLD – the building blocks to maps
  - Spatially
  - Temporally

Caption for Figure on Slide 3

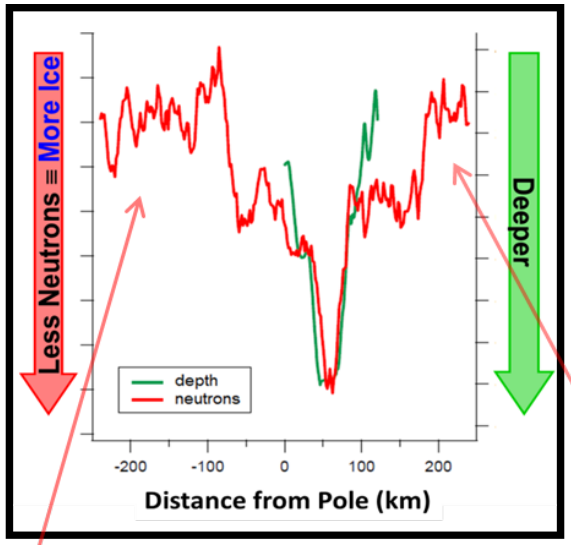
LEND South Pole Hydrogen Deposits and Lunar Topography: A trace of a LRO spacecraft orbital track – shown above in red on the LEND hydrogen South pole topography map – through the Shoemaker crater neutron suppressed region. The plot shows that the neutron suppression – shown in green – corresponds directly with the Shoemaker crater LRO topography – shown in red.

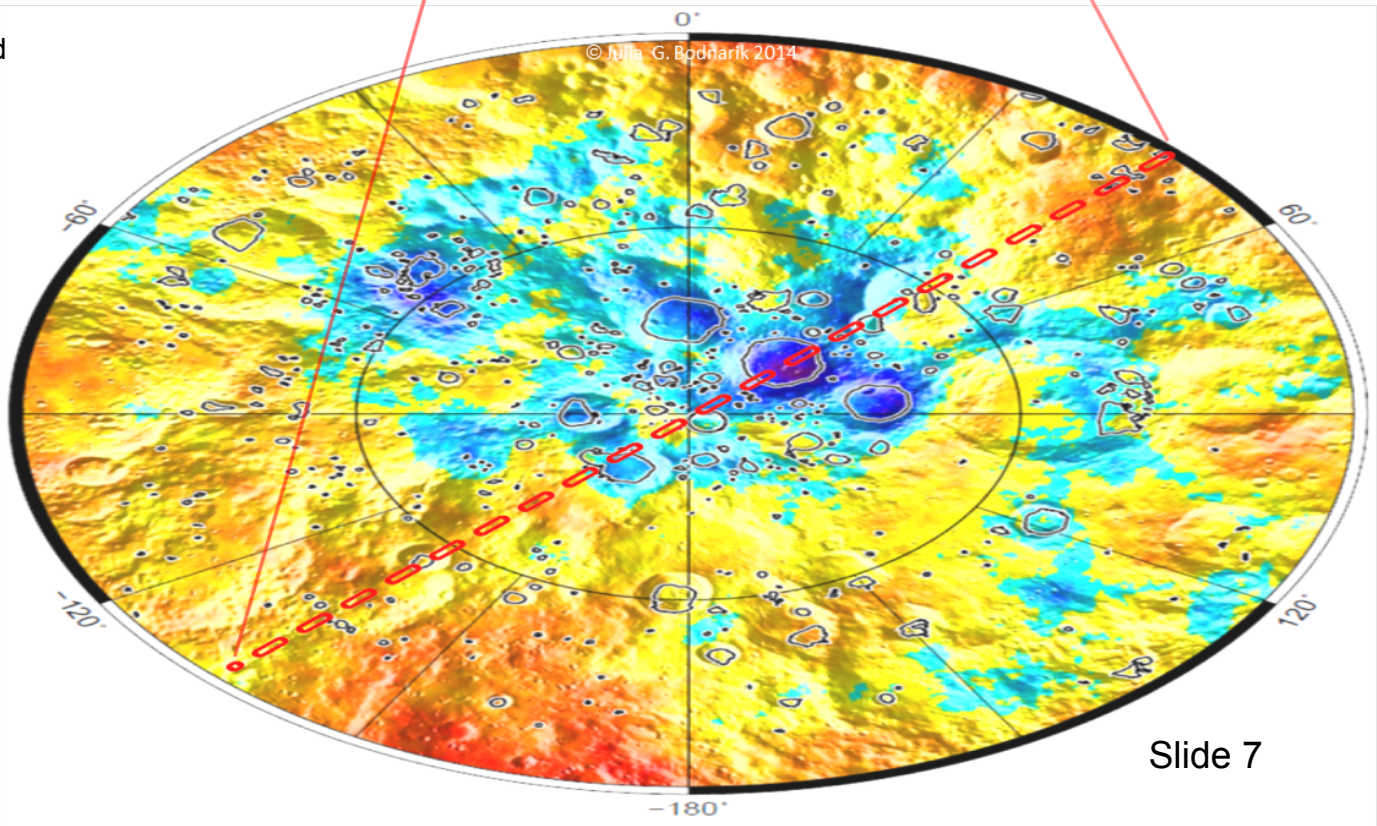
The bottom lunar SP map was created using IDL and GMT in the following way:

1. Created SP LEND CSETN v294 boxcar smoothed polar stereo graphic map.
2. Converted cps map to H ppm map and performed a uniform background substraction.
3. Exported data into GMT format for mapping
4. Using GMT, overlayed LEND data (shown in color) on top of LOLA topography and added PSRs.
5. Added trace for top graph to the plot.

Top plot was created in the following way:

1. Used IDL to do LOLA and LEND traces through Shoemaker crater as a function of distance in km from the pole.
2. Exported data to Igor pro to create plot.



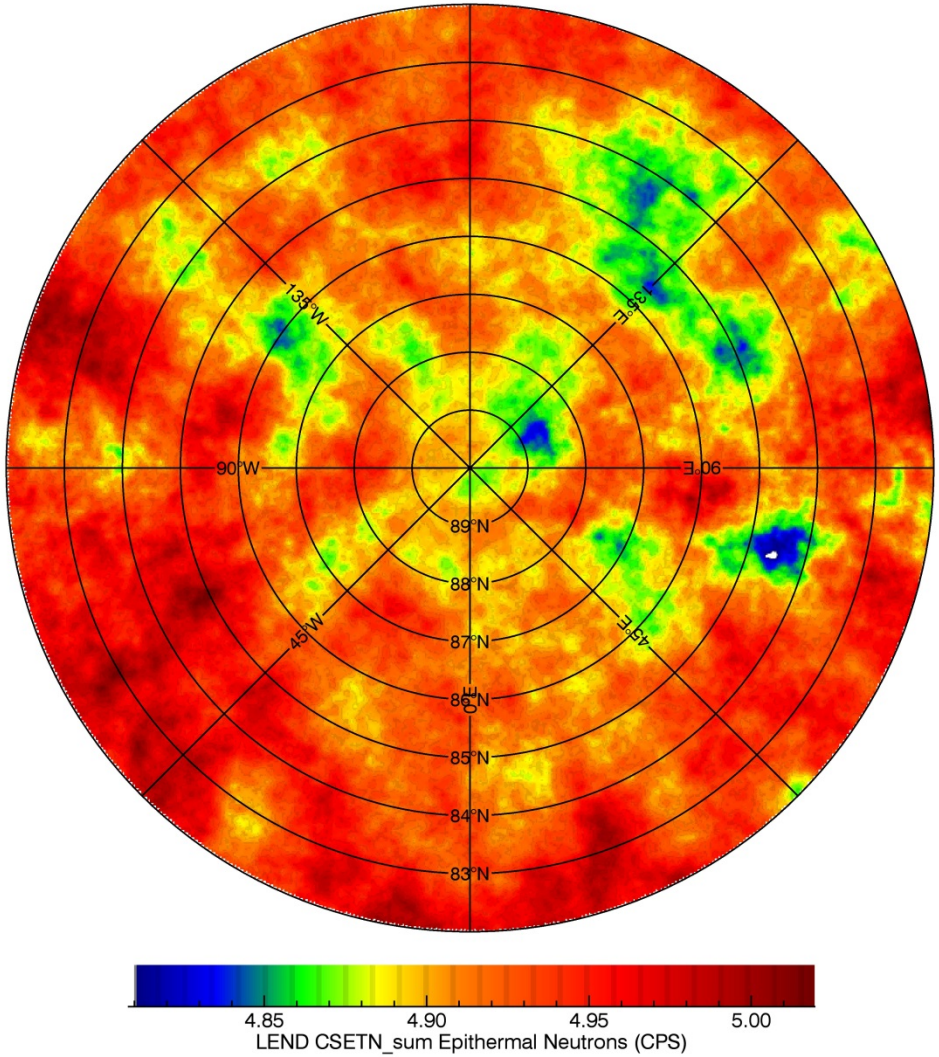


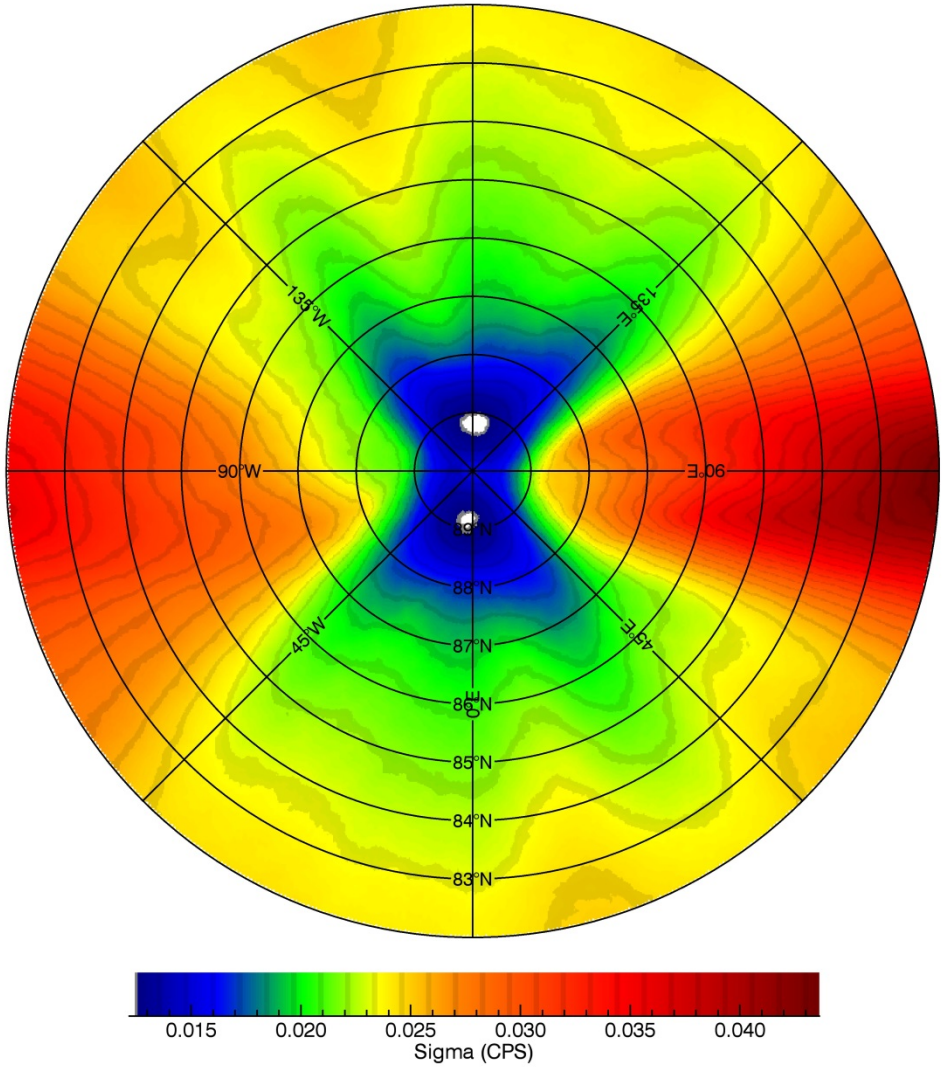
CSETN sum Epithermal Neutron **v29r** Boxcar Smoothed Weighted Mean and Sigma Maps

JGB June 2014 DLDs; Applied **SP orbital averages**, **nadir limit = 1.9 deg.** & **No UA alt. corr.**; **Circular Orbit;**

Time Period = [9/15/2009 19:35:59 UTC, 12/11/2011 17:17:31 UTC] = [274736160 LROsec, 345316652 LROsec]; outTo = 82 deg. lat; /interp

Created using IDL.

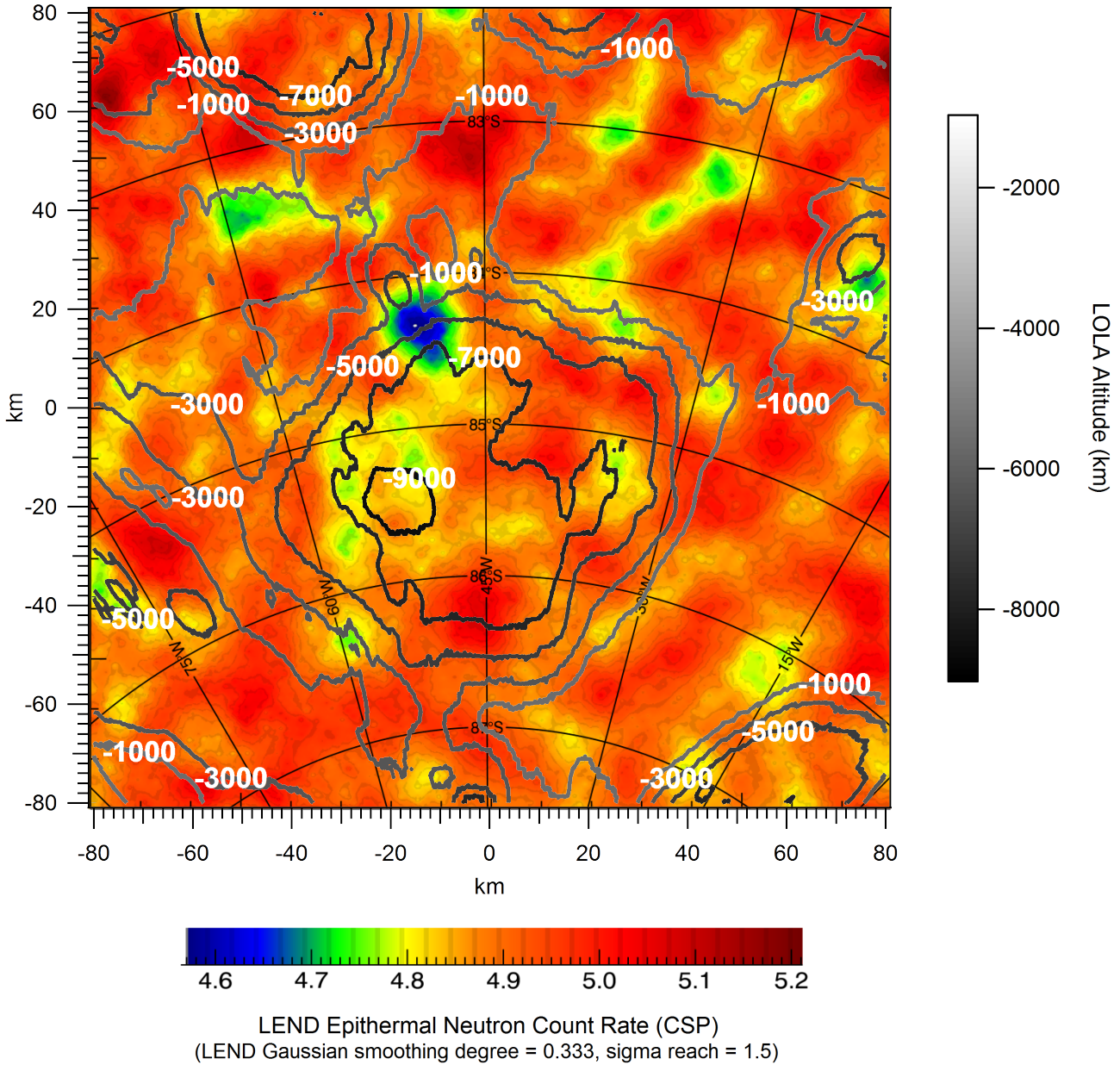




LOLA Elevation Contour Map Overlay on LEND Epithermal Neutron Smoothed WM Map
(South Pole, Cabeus crater region, [c_lat, c_lon] = [-44.7, -84.9], extent = 80 km)

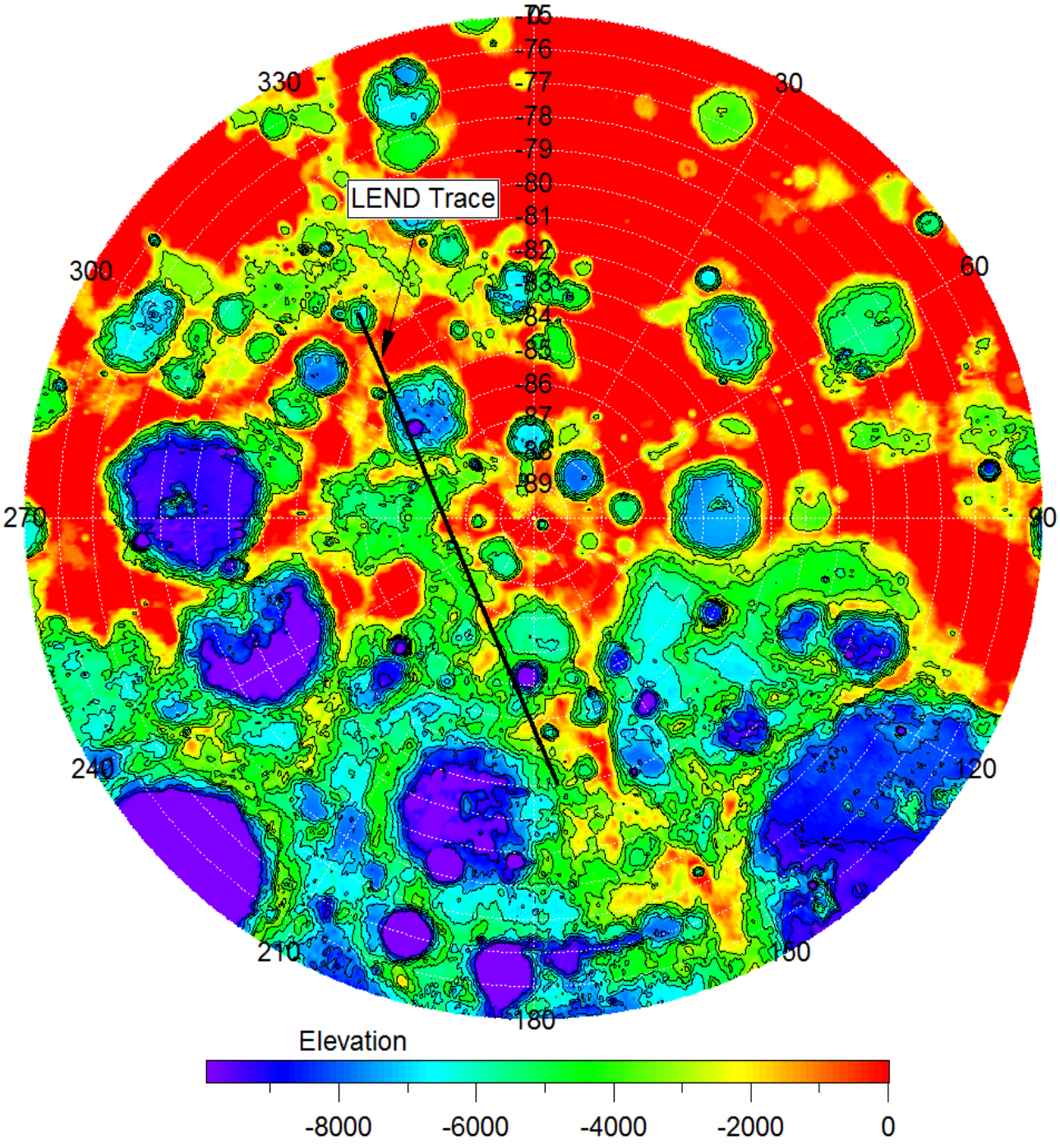
This LEND CSETN Gaussian smoothed weighted mean map was created in the following way :

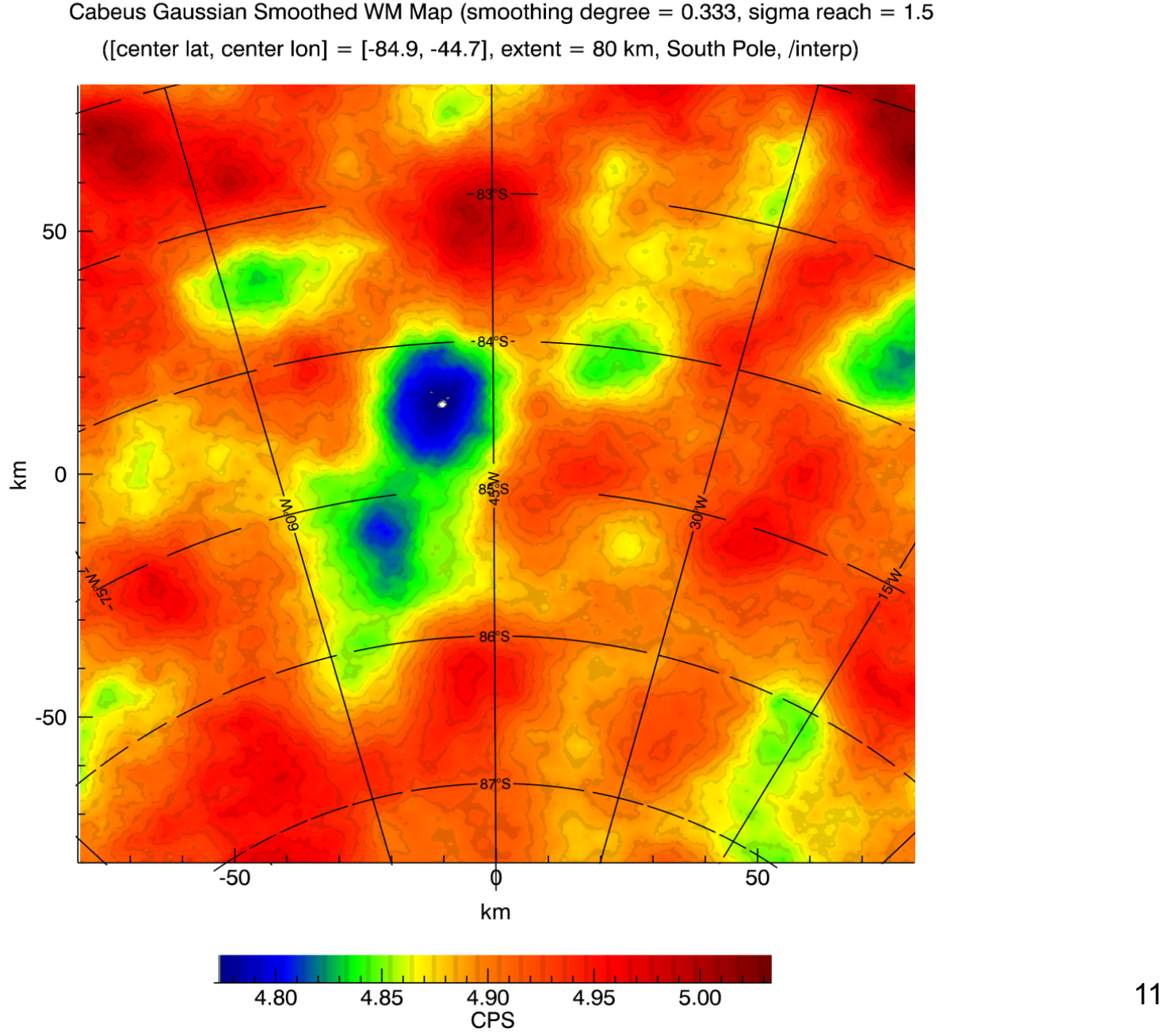
1. Used IDL to create a km map centered on Cabeus crater with a polar stereo graphic grid overlaid on the map.
2. Exported LEND image into Igor Pro.
3. Imported LOLA data for the region into Igor Pro.
4. Created LOLA contour map and overlayed it on LEND image in Igor Pro.
5. Added legends



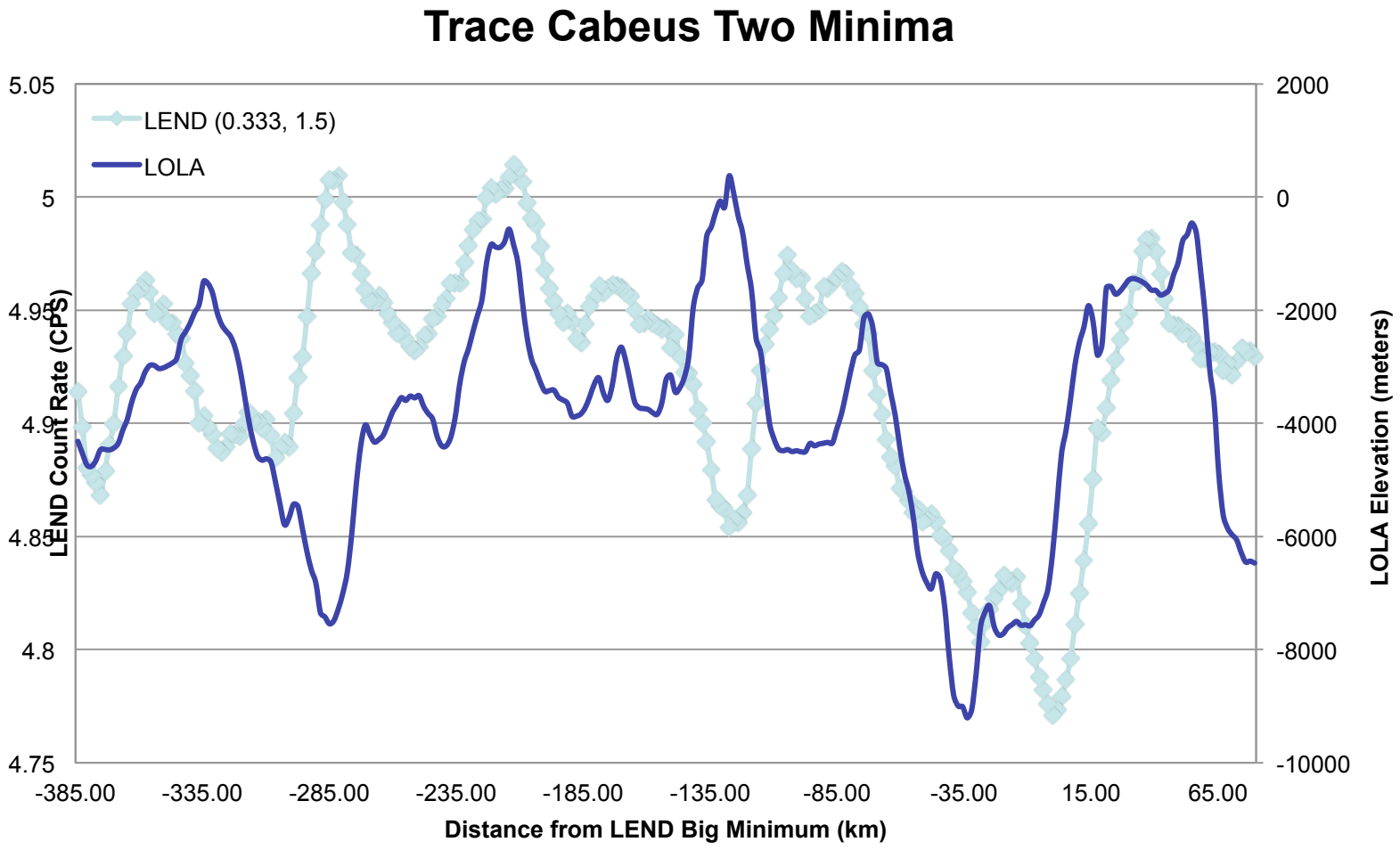
This LEND CSETN smoothed weighted mean map was created in the following way :

1. Used IDL to create smoothed wm map and exported data LEND and LOLA data to Igor Pro.
2. Used Igor pro to create LEND data map with LOLA contour overlay



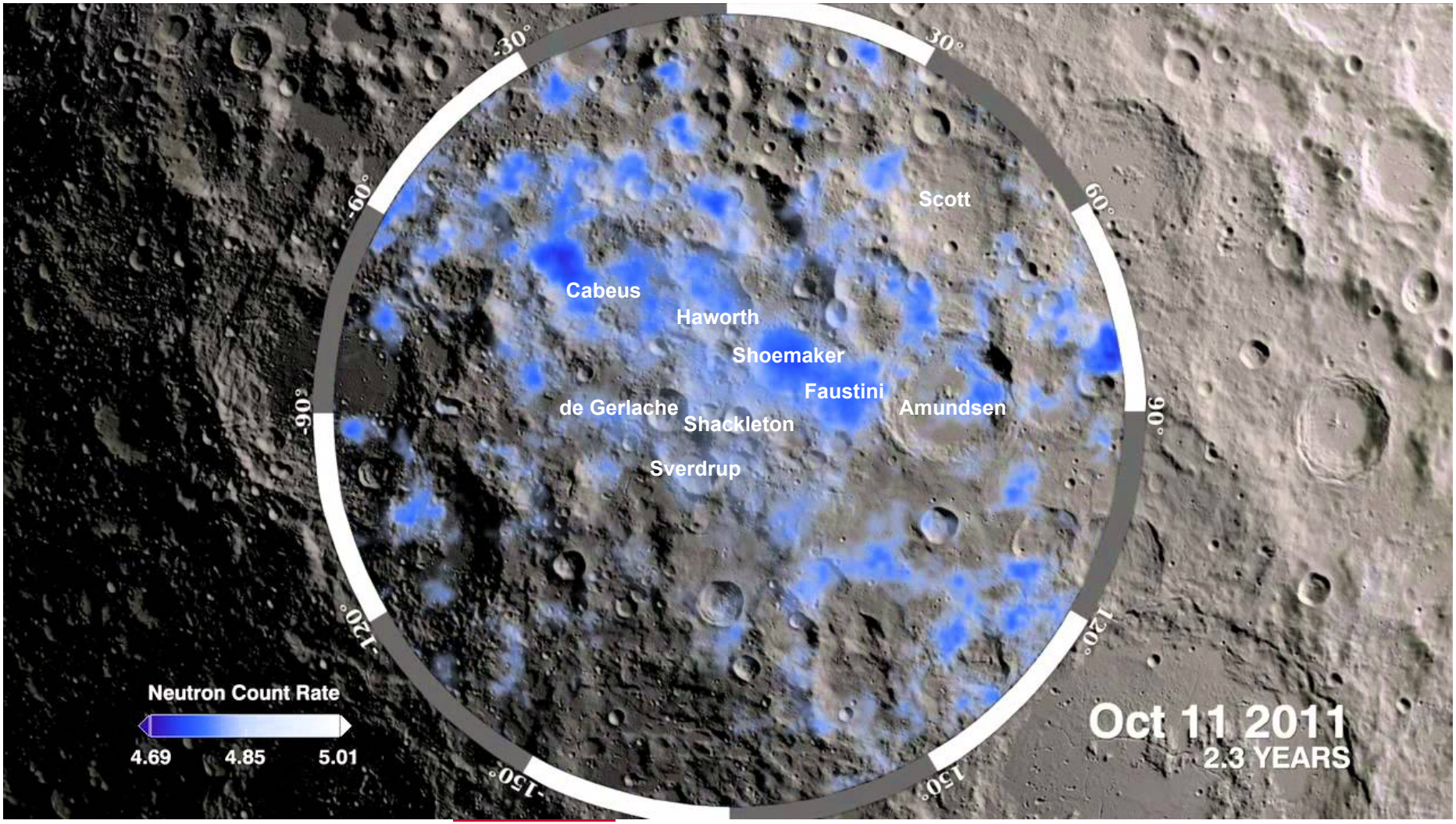

Cabeus Gaussian Smoothed WM Map (smoothing degree = 0.333, sigma reach = 1.5
([center lat, center lon] = [-84.9, -44.7], extent = 80 km, South Pole, /interp)
83°S
84°S
85°S
86°S
87°S
45°W
60°W
75°W
30°W
15°W
50
0
-50
km
-50
0
50
km
4.80
4.85
4.90
4.95
5.00
CPS

This trace was created using IDL and exporting data into Excel. The corresponding LEND IDL images are to the left



Polar Ice Deposits: LRO evidence shows that the Moon's polar regions, especially PSRs, are cold enough to retain water ice. Over several years, LEND has scanned the Moon's South pole measuring how much hydrogen is trapped in the soil. Areas with suppressed neutron activity – shown above in blue – show the highest concentration of hydrogen atoms, strongly suggesting the presence of H_2O molecules.

This image is a snapshot of the lunar SP created for a NASA Goddard Space Flight Center movie for Tim McClanahan. It is an overlay of LEND CSETN data (shown in the blue to white continuum) created using IDL on lunar topography. The names of the craters were also added to the image.


-30°
30°
-60°
60°
-90°
90°
-120°
120°
-150°
150°
Scott
Cabeus
Haworth
Shoemaker
Faustini
Amundsen
de Gerlache
Shackleton
Sverdrup
Neutron Count Rate
4.69
4.85
5.01
Oct 11 2011
2.3 YEARS

Animation

- South Pole fly-in